Things of science

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SPACE-AGE MINERALS

Unit No. 266

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SPACE-AGE MINERALS

This unit of THINGS of science consists of six mineral specimens, each containing an element in its chemical formula that plays an important role in man's conquest of space.

Many new materials: high temperature metals and ceramics; new lightweight sources of power; electrical gadgets by the hundreds requiring new insulators and new conducting materials have all been developed in response to space-age needs.

The source of all these new chemicals and metals is still the rocks and minerals of the earth. Many of these space-age minerals were not considered valuable in the days when gold, silver, lead, iron and copper were eagerly sought.

Now the march of science and technology has created a demand for boron, beryllium, cesium and other exotic elements.

Experiment 1. First identify your specimens in this THINGS of science unit.

KERNITE—Contains boron; long glassy crystals in polyethylene bag.

BERYL—Contains beryllium; white,

streaked with yellow or black; may be pale yellow or pale green.

SPODUMENE—Contains lithium; color varies from pink to green-gray.

WOLFRAMITE — Contains tungsten; black aggregate speckled with white quartzite.

POLLUCITE—Contains cesium; white.

COFFINITE—Contains uranium; dark gray or black in sandstone; looks like coal.

This unit will help you understand the important role of rocks and minerals and the chemicals they contain in man's existence and will give you some indication of the still unknown power that lies buried in the rocks that compose much of the earth's surface.

BORON (B)

Experiment 2. Examine your specimen of kernite. Notice the long splintery structure of the crystals and how delicate they are. Kernite is packaged in the polyethylene bag because it is too cleavable and could not be crushed and sized as were the other specimens.

Many minterals tend to break in a definite smooth flat plane. This characteristic is known as cleavage and is re-

lated to the arrangement of the atoms within the crystals of the mineral.

Notice the flat planes formed by the crystals of kernite. This mineral cleaves very easily. Break some of your kernite apart along the cleavage lines and see how readily they separate.

The cleavage fragments are colorless and transparent and have a high luster.

Place some of the kernite crystals in water. Do they turn white? What happens to them if left standing in the water? If the water is heated a little, the crystals will dissolve more quickly.

Kernite is a hydrous sodium borate and is the chief source of boron.

Boron has many interesting properties of use to space-age technology. Combined with hydrogen it has potential as a rocket fuel.

The element boron is lightweight and tough, which qualifies it for consideration in rocket construction.

In a special form, it exhibits a hardness with the same range as diamond which is the hardest material in nature.

Another very useful property of boron is that it absorbs (soaks up) neutrons,

one of the subatomic particles. This property makes it useful as a neutron shield material when neutrons must be kept in or out of some particular area.

Although space-age uses of boron are very new, boron is familiar to most of us in the form of borax, the household bleaching and cleaning agent.

BERYLLIUM (Be)

Experiment 3. Take your beryl specimen and note its color and observe its greasy, glassy luster. It is usually white, pale yellow or pale green.

This mineral breaks into irregular pieces with no definite cleavage. Examine your sample and note its irregular shape.

Beryl has been long known as one of the major gem stones. It has now found new importance in the space age. When green it is an emerald, when blue, an aquamarine and when pink, morganite.

From this mineral, which is a silicate of beryllium and aluminum, the important metal beryllium is extracted.

Beryllium is the most suitable metal known to slow down neutrons in nuclear reactors. Beryllium metal is very lightweight which makes it excellent material

for spacecraft. The lighter the spacecraft, the less fuel needed to get it into space.

The electrical conductivity of beryllium is high enough so that it may replace copper in space applications where weight is of great importance.

Beryllium as a metal also possesses great strength and has a high melting point. These properties make beryllium valuable in spacecraft structures.

LITHIUM (Li)

Experiment 4. Your specimen of spodumene may be white or vary in shade from pale pink to pale green-gray.

Is its shape irregular like the beryl specimen, or more regular? Does it show a more definite cleavage?

Spodumene breaks into splintery fragments like kernite but not with smooth shiny surfaces.

Hold it up to the light. Is it opaque or translucent? Note its glassy luster.

Spodumene, a lithium aluminum silicate, is the source of another lightweight metal important in spacecraft use, lithium. Lithium combined with other metals makes lightweight alloys of high strength. It is also a constituent of rocket fuels.

Recently, research has shown lithium to be of value in metal-cooled atomic reactors. Used in glass, lithium improves the resistance of the glass to thermal shock. This is important in space vehicles where the outside temperature in outer space is extremely cold, but upon re-entry into the earth's atmosphere the outside surface of a spacecraft is heated to extremely high temperatures.

Thus, scientists and engineers are continually finding new uses for this very versatile element.

TUNGSTEN (W)

Experiment 5. Examine your wolframite specimen carefully. It is a shiny aggregate rock and mixed into it are pieces of its host rock quartzite. Notice its submetallic luster.

Wolframite usually has a perfect cleavage on its fracture face. Is this true of your specimen?

This mineral, the most important source of tungsten or wolfram, is an iron-manganese tungstate which varies in color from black to red-brown.

Tungsten, because of its high melting point is extremely valuable for space-age applications.

In re-entering the earth's atmosphere, spacecraft are subjected to intense heat and tungsten which can withstand high temperatures finds many uses here.

You have observed this property of tungsten in the ordinary light bulb. The filaments that produce the light are made of tungsten and withstand the intense electrical heat without melting.

The mighty jet engines which propel our planes and spacecraft use tungsten in many ways. Many parts of the engines are coated with tungsten to prevent melting.

The exhaust nozzles of modern missiles that must be able to withstand high temperatures and still be able to hold their shape utilize tungsten's high temperature property. Any change in shape of the rocket motor could decrease its power and efficiency.

CESIUM (Cs)

Experiment 6. Pollucite, the source of cesium is always white. Notice that it does not break in cleavage fragments and that its shape is irregular. Is it transparent like kernite?

While sometimes glassy it is duller than beryl. How does its luster compare

with the luster of other specimens?

Pollucite is a hydrous cesium aluminum silicate and is the source of the rare and exotic element cesium.

Cesium is one of the most important elements in the space age. New rocket engines are being developed that make use of cesium's ability to lose one of its electrons easily. This is the new and exciting ion engine which will someday be used to help explore the solar system. Now under development is a new ion engine that will keep a satellite in position in space so that it will be continuously in the same position relative to the earth.

Tungsten is also needed to help the cesium in this space-age use as a fuel to propel rockets in outer space. Cesium is also used today in a precise time-measuring machine.

Split second accuracy is needed to put our rockets on their proper course. Cesium helps to do just that because its atoms can be used as accurate time keepers.

URANIUM (U)

Experiment 7. The black sooty material coffinite, is embedded in sandstone.

Pure specimens of coffinite look like coal. Some have a dark gray slaty appearance.

Coffinite is essentially a uranium hydrous silicate, but it always contains small amounts of many other elements.

This ore is a source of uranium, but the small amount of radioactivity in this specimen is not harmful.

Uranium owes its main usefulness to its radioactivity. The uranium atom is able to split, releasing large quantities of energy. As a fuel a little uranium will go a long way.

In the exploration of the solar system, much fuel will be needed because of distance and time. The heavier bulkier fuels now used will have to be displaced by lightweight high-energy fuels. In one pound of uranium energy equivalent to 200,000 gallons of diesel fuel is available.

Uranium can also serve as a source of radiation for sterilization and other uses. In the space age uranium plays a very important part.

By studying these minerals carefully you will be able to recognize them should you come across them again when mineral hunting or visiting museums.

All minerals have distinctive physical properties. One of these is hardness.

Hardness is measured by the ability of a mineral to scratch all materials of lesser hardness and be scratched by all things of greater hardness.

To classify the minerals Mohs' scale of hardness is used. The ten degrees of hardness with their respective mineral examples are given below. The higher the number, the harder the material.

1. talc
2. gypsum
3. calcite
4. fluorite
5. apatite
6. feldspar
7. quartz
8. beryl
9. corundum
10. diamond

Using a penny and a piece of broken window glass you can test the minerals in this set and classify them into three groups.

Any mineral that will scratch a penny has a hardness of 3 or more and if it scratches the glass, its hardness is at least 5½, or between 5 and 6.

Experiment 8. Try scratching the penny with kernite. Can you? Scratch the kernite with the other minerals in your unit. Can all of them scratch it?

Kernite is the softest of the minerals in your unit and you will find that all of them will scratch it.

Since kernite will not scratch the penny, its hardness must be less than 3. Actually its hardness is 2½. Can you scratch it with your fingernail? All minerals of 2½ or less hardness can be scratched with the fingernail.

Experiment 9. Scratch the penny and piece of glass with each of your other specimens and group them according to their hardness: less than 3, 3 to 5, and 5 and over. Check to see if the harder specimens will scratch the softer ones.

Experiment 10. When using your wolframite specimen be careful not to scratch with the quartzite which is distributed throughout the specimen. Quartzite which has a hardness of 7 will scratch the glass. Wolframite, 4½ on Mohs' scale, will not scratch glass. Does it scratch the penny?

Experiment 11. The specimens in your unit that will scratch glass are beryl which has a hardness of 8 and spodumene and pollucite both of which are 6½. Do your results check with the hardness scale?

Can you scratch the spodumene and pollucite with beryl?

Coffinite is scattered throughout the sandstone and cannot be tested directly.

Experiment 12. Kernite has an interesting property known as exfoliation. Hold several needles of kernite in a flame with a metal holder or forceps being careful not to burn your fingers.

What happens? The crystals will puff up into white worm-like forms. The mineral contains water in its structure which is driven off as steam when the mineral is heated.

Very few minerals and none of the others in this unit have this property.

Experiment 13. Coffinite which contains uranium is the only radioactive mineral in this group of space age mineral specimens.

To demonstrate this radioactivity you can place this mineral on a piece of shielded unexposed film. Be careful not to expose the film to any light and work in a darkened room.

After several days, develop the film. If the specimen contains enough uranium, the film will show that the mineral has

"taken its own picture." If you do not get a picture try again, exposing the mineral to the film for a week or ten days.

Take a small metal object such as a small key and place it between the specimen and an unexposed film. Let it stand a few days and then develop the film. A rough outline of the metal object will show on the film.

Henri Becquerel discovered the radioactivity of uranium in 1896 by accident using exactly the same procedure.

Where are the minerals found that contain these important space-age elements? Of the six minerals in this kit, five came from the Black Hills of South Dakota and one (kernite the boron mineral) came from California.

Not every area or state will have many of these rare minerals. In the future geologists will be needed to find new sources of these elements, mining engineers will be needed to design methods of getting them from their resting place in the earth and metallurgists, ceramists, chemists, physicists and engineers will be needed to discover new and better ways for mankind to live here on earth and in outer space with the aid of these little known elements.

Appreciation is expressed to Dr. George Rapp, Jr., Associate Professor of Mineralogy, South Dakota School of Mines and Technology, Rapid City, for his cooperation in producing this unit of THINGS of science.

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Production by Ruby Yoshioka

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Cut out label on other side and put on end of box

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12 monthly experimental kits—$5.00
(Add $1 for outside U.S.A. addresses)